

# **ALBERTA ENVIRONMENT SUMMARY REPORT ON 2005 GREENHOUSE GAS EMISSIONS**

**Alberta**  
ENVIRONMENT



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## Executive summary

The Government of Alberta is committed to taking action on climate change. Beginning with its Climate Change Action Plan - *Albertans & Climate Change: Taking Action*, released in October 2002, the Government of Alberta identified a number of strategies the province would use to address climate change. One of these actions included the development of a mandatory reporting program for large industrial emitters in Alberta.

Beginning in November 2004, large industrial emitters in the province were required to submit an annual report on their previous year's greenhouse gas emissions. The *Specified Gas Reporting Program* requires any Alberta industrial facility that emits more than 100 kilotonnes (kt) of greenhouse gases, expressed as carbon dioxide equivalent, to report their emissions to Alberta Environment through a secure electronic data reporting system. Beginning with 2004 reporting, the Alberta system was harmonized with the *National Mandatory Greenhouse Gas Reporting Program*.

### Alberta in 2005

Alberta's growing economy presents unique challenges for addressing greenhouse gas emissions and climate change. Our province has specialized resource-based industries that are less prevalent in other parts of Canada. We are also experiencing strong economic growth, which is usually accompanied by increased greenhouse gas emissions.

For the 2005 reporting year, 101 Alberta facilities reported total greenhouse gas emissions of 109 megatonnes (Mt). This represents an increase of three facilities reporting compared to the 2004 reporting year, with emissions remaining nearly unchanged (a decrease of 0.1 Mt).

Alberta facilities accounted for 39 per cent of the 2005 total Canadian reported greenhouse emissions, captured under the *National Mandatory Greenhouse Gas Reporting Program*. Alberta facilities were the source of 40 per cent of emissions of carbon dioxide, 43 per cent of emissions of methane, 26 per cent of emissions of nitrous oxide and 15 per cent of emissions of hydrofluorocarbons.

Ninety-five per cent of the total reported Alberta greenhouse gas emissions were in the form of carbon dioxide. The remainder was in the form of methane, nitrous oxide and hydrofluorocarbons. There were no Alberta facilities that reported emissions of perfluorocarbons or sulphur hexafluoride for 2005 reporting. The largest emitting industrial sectors were power plants (47 per cent), oil sands facilities (19 per cent) and gas plants (eight per cent).

Ninety-four Alberta facilities reported greenhouse gas emissions in both the 2004 and 2005 reporting years. The net change in emissions for these 94 facilities was a decrease of 0.3 megatonnes. It is unclear if the changes in emissions between reporting years are due to refinements in calculation methods or absolute changes in emissions.

The reporting system allows specified gas reporters to request that portions of their report be kept confidential, for a period of up to five years, on the basis that the information is commercial, financial, scientific or technical detail that would reveal proprietary business, competitive or trade secret information about a specific facility, technology or corporate initiative. Seven Alberta facilities requested confidentiality for their reported greenhouse gas information; a significant decrease as compared to past reporting years. All seven of these facilities were granted confidentiality for emissions by source category and one facility was also granted confidentiality for gas totals.

### **Key findings (2004 National Greenhouse Gas Inventory)**

The *National Mandatory Greenhouse Gas Reporting Program* just covers industrial sources, whereas the *National Greenhouse Gas Inventory* includes estimates of emissions from other sources including transportation, agriculture, construction, commercial, institutional and residential. The *2004 National Greenhouse Gas Inventory* estimated there was a total of 235 megatonnes of greenhouse gases emitted from all sources in Alberta. Seventy-eight per cent of these emissions were carbon dioxide, 17 per cent were methane and five per cent were nitrous oxide.

Six sources were responsible for almost 90 per cent of 2004 Alberta greenhouse gas emissions. These sources were fossil fuel industries (37 per cent), electricity and heat generation (22 per cent), transportation (13 per cent), agriculture (seven per cent), industrial processes (six per cent) and mining (five per cent). Combining all industrial sources into a single category showed that industrial sources were responsible for 73 per cent of total greenhouse gas emissions in Alberta.

Based on comparisons to the *National Greenhouse Gas Inventory*, the current industry reporting program captures 47 per cent of total greenhouse gas in Alberta. The reporting program captures 57 per cent of carbon dioxide, nine per cent of methane and 15 per cent of nitrous oxide emissions in the province.

Total absolute Alberta greenhouse gas emissions from all sources have increased by 40 per cent since 1990, while emissions intensity (kilotonnes of greenhouse gas emissions per million dollars GDP) decreased by 16 per cent over the same period. Alberta is therefore more than one quarter of the way to meeting its target of reducing emissions intensity by 50 per cent below 1990 levels by 2020. Furthermore, Alberta is over half way to meeting its interim 2010 target of a 30 per cent reduction in greenhouse gas emissions intensity.

### **Future activities on climate change**

Alberta is planning future amendments to the *Climate Change and Emissions Management Act* including development of regulations to establish emissions intensity reduction targets for industrial facilities. The amendments and regulations reaffirm Alberta's commitment to manage greenhouse gases and together outline the Alberta regulatory approach to managing emissions from large industrial facilities.



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## Abbreviations

AENV:	Alberta Environment
AB:	Alberta
BC:	British Columbia
CH <sub>4</sub> :	methane
CO <sub>2</sub> :	carbon dioxide
CO <sub>2</sub> -e:	carbon dioxide equivalent
EDR:	Electronic Data Reporting System
GDP:	Gross Domestic Product
HFCs:	hydrofluorocarbons
kt:	kilotonne
MN:	Manitoba
Mt:	megatonne
N <sub>2</sub> O:	nitrous oxide
NB :	New Brunswick
NL :	Newfoundland & Labrador
NS :	Nova Scotia
NT :	Northwest Territories
ON :	Ontario
PE :	Prince Edward Island
PFCs:	perfluorocarbons
QC:	Quebec
SF <sub>6</sub> :	sulphur hexafluoride
SK :	Saskatchewan







## 1.0 Alberta taking action on climate change

### 1.1 Goals and policies

The Government of Alberta is committed to reducing greenhouse gas emissions and developing an effective approach to responding to the potential risks of climate change. Alberta's plans are outlined in *Albertans & Climate Change: Taking Action*<sup>i</sup>. The plan provides a comprehensive framework to reduce greenhouse gas emissions while maintaining a prosperous economy over the long term. By 2020, Alberta will cut greenhouse gas emissions in the province relative to Gross Domestic Product (GDP) by 50 per cent of 1990 levels. This should be approximately a 60 Megatonne (Mt) reduction in greenhouse gas emissions below expected business-as-usual levels. By 2010, it is estimated that Alberta will have achieved an emissions intensity improvement of roughly 20 Mt below business-as-usual levels. Improvements in emissions intensities will improve the efficiency of facility operations, which in turn will increase the competitiveness of Alberta industries. The Government of Alberta continues to encourage the use of best practices and technologies.

There are three main components of the *Specified Gas Reporting Program*<sup>ii</sup> - the *Specified Gas Reporting Standard*<sup>iii</sup>, the *Specified Gas Reporting Regulation*<sup>iv</sup>, and the *Climate Change and Emissions Management Act*<sup>v</sup>. *Alberta's Climate Change Action Plan* identifies the provincial *Specified Gas Reporting Program* as an important aspect of managing climate change. Information gathered under the program is needed to assist both the province and industry in characterizing emission sources and identifying opportunities for emission reductions. The program will allow the Government of Alberta to monitor progress of specific Alberta emission reduction strategies, such as setting greenhouse gas emission targets, establishing emission-trading systems, implementing greenhouse gas emissions reduction technologies for industry and promoting reductions in emissions intensity.

### 1.2 Reporting program

The Alberta *Specified Gas Reporting Program*<sup>ii</sup> requires that all large Alberta industrial facilities emitting more than 100 kilotonnes (kt) of greenhouse gases in carbon dioxide equivalent (CO<sub>2</sub>-e) units per year (based on the sum of direct emissions of carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulphur hexafluoride (SF<sub>6</sub>)) report their greenhouse gas emissions to Alberta Environment. Facilities are required to use an Electronic Data Reporting (EDR) system to submit their greenhouse gas reports, which is administered by Statistics Canada.

Alberta harmonized its *Specified Gas Reporting Program* with the *National Mandatory Greenhouse Gas Reporting Program*<sup>vi</sup> beginning with 2004 greenhouse gas reporting. The result is that facilities are required to report only once through the EDR to satisfy both provincial and federal reporting requirements. The Alberta data collected using the

EDR is provided to both Alberta Environment and Environment Canada. Alberta facilities are required to submit separate Statements of Certification and requests for confidentiality directly to both Environment Canada and Alberta Environment via mail or courier.

The complete reporting requirements for 2005 reporting are outlined in the March 2006 version of the *Specified Gas Reporting Standard*<sup>ii</sup>. The Alberta *Specified Gas Reporting Program* will continue to evolve in future years to gather the necessary emissions data for regulatory, industrial and public purposes.

### **1.2.1 Changes for 2005 reporting**

One of the key changes to the *Specified Gas Reporting Program*<sup>ii</sup> included replacement of the “other emissions” source category with the “on-site transportation emissions” and “waste and wastewater emissions” source categories. The “fugitive emission” source category was also replaced with the more specific “venting and flaring emissions” and “other fugitive emissions” source categories.

The reporting requirement for hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulphur hexafluoride (SF<sub>6</sub>) were revised to include only those emissions of these gases from industrial process or industrial product use. In addition, this change was also made for calculating whether a facility exceeded the reporting threshold (HFC, PFC and SF<sub>6</sub> only).

## **1.3 Future Regulation**

Alberta is planning future amendments to the *Climate Change and Emissions Management Act*<sup>iii</sup> that will include regulations to establish emissions intensity reduction targets for industrial facilities. These steps will reaffirm Alberta’s commitment to manage greenhouse gases and outline the Alberta regulatory approach to managing emissions from large industrial facilities.

### **1.3.1 Climate Change and Emissions Management Act**

The *Climate Change and Emissions Management Act* is Alberta’s primary legislation for regulating greenhouse gas emissions in the province. The act provides the regulatory framework necessary for setting provincial, sectoral and/or facility level targets, reporting as well as compliance and enforcement requirements. The act was passed in 2003 but was not proclaimed. Sections of the act were proclaimed when the *Specified Gas Reporting Regulation*<sup>iv</sup> was passed in 2004. Amendments to the act and proclamation of the remaining elements are necessary to provide the appropriate legislative authority for the implementation of the new greenhouse gas regulations.

### **1.3.2 Specified Gas Emitters Regulation**

The *Specified Gas Emitters Regulation* is a new strategic regulation that will confirm Alberta’s intent to set greenhouse gas intensity limits for large emitters of greenhouse



gases in Alberta. The regulation represents the next important step in delivering on the current *Climate Change Action Plan*<sup>i</sup> and addressing new emissions from a growing economy. It is based on the Government of Alberta's commitment to drive prudent emission intensity reductions in the short-term and encourages investment in technological change to support longer-term economic and environmental objectives.

The proposed amendments and regulations have been developed with significant input from industry and other stakeholders. The intent is to have both in place in time for the 2008 greenhouse gas emissions reporting year.

## 2.0 Confidentiality

### 2.1 Confidentiality request process

The confidentiality provisions for the *Specified Gas Reporting Program*<sup>ii</sup> are set out in section 5 of the *Specified Gas Reporting Regulation*<sup>iv</sup>, AR 251/2004. This section permits facilities that report greenhouse gas emissions to Alberta Environment to request confidentiality for some or all of their submitted data. The request must be based on the criteria set out in section 5 (1) and (2) of the regulation. The Director under the act has 90 days to reach a decision and can grant parts or the entire request, which results in information being held as confidential for up to five years.

### 2.2 Confidentiality requests and decisions

For the 2005 reporting year seven Alberta facilities requested and were granted confidentiality. The number of facilities requesting confidentiality for the submitted greenhouse gas data declined significantly from the two previous reporting years. For the 2003 reporting year 20 facilities requested confidentiality and for the 2004 reporting year 21 submitted requests for confidentiality. In 2004 nine facilities were granted some form of data confidentiality, of which seven submitted a confidentiality request for the 2005 reporting year.

Six of the seven confidentiality requests asked for detailed source-level greenhouse gas emissions data to be kept confidential and one request asked for detailed source-level and one request asked for detailed source-level and gas total greenhouse gas emissions be kept confidential. [Table 1](#) provides the decisions on the 2005 confidentiality requests. All seven of the facilities that requested confidentiality for 2005 specified gas reporting were granted their requests for a period of five years, starting from the June 1, 2006 reporting deadline.

**Table 1: 2005 confidentiality decisions**

Company Name:	Facility Name:	Decision:
Imperial Oil	Cold Lake	Section III (A) deemed confidential for 5 years.
Petro-Canada	Edmonton Refinery	Section III (A) deemed confidential for 5 years.
Graymont	Exshaw	Section III (A and C) deemed confidential for 5 years.
Albian Sands Energy Inc.	Muskeg River Mine	Section III (A) deemed confidential for 5 years.
Shell Canada Limited	Scotford Refinery	Section III (A) deemed confidential for 5 years.
Shell Canada Limited	Scotford Upgrader and Upgrader Cogeneration	Section III (A) deemed confidential for 5 years.
Imperial Oil	Strathcona Refinery	Section III (A) deemed confidential for 5 years.

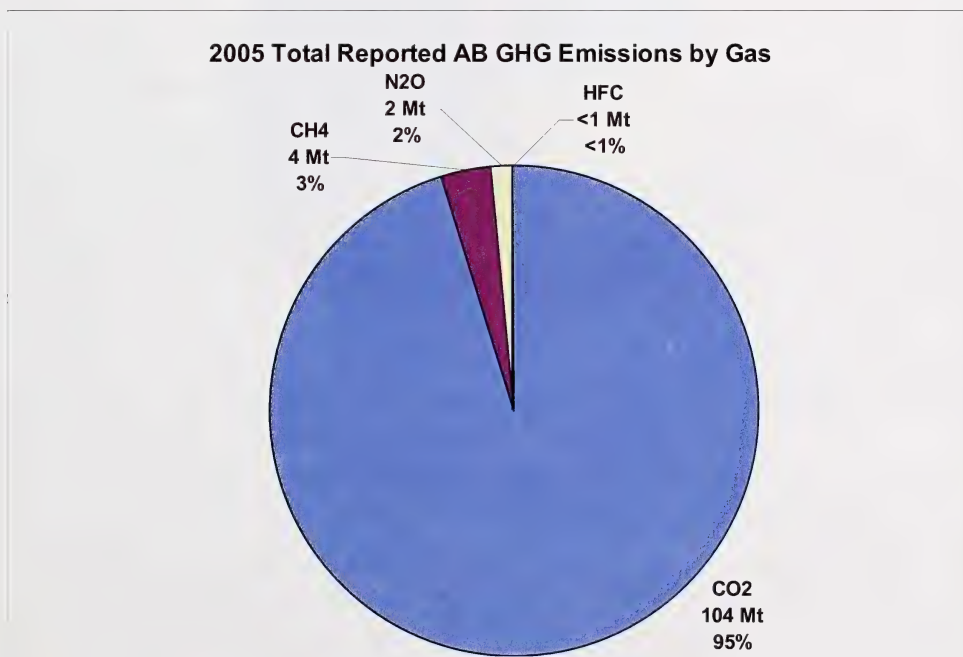


### 3.0 2005 reported emissions

**Note:** All emissions numbers reported in this document are in carbon dioxide equivalent units.

#### 3.1 Total reported GHG emissions

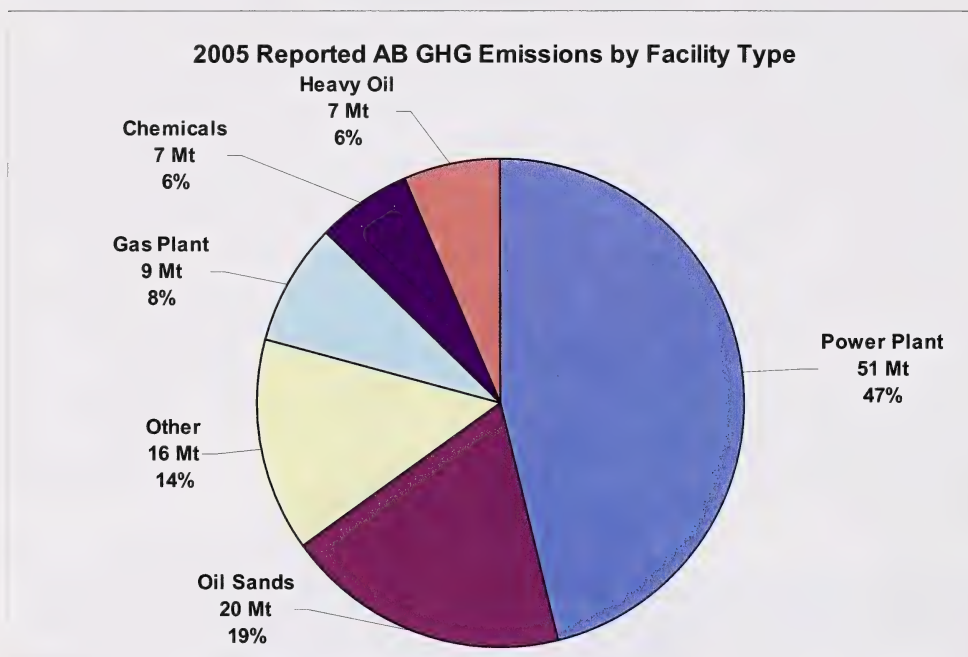
Total reported greenhouse gas emissions is the sum of emissions of carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), species of hydrofluorocarbons (HFC), species of perfluorocarbons (PFC) and sulphur hexafluoride (SF<sub>6</sub>) all converted to carbon dioxide equivalent units using the global warming potentials specified in the *Specified Gas Reporting Standard*<sup>iii</sup>. There were 101 Alberta facilities that submitted specified gas reports to Alberta Environment for the 2005 reporting year. [Table 3](#) in the appendix provides the gas totals for the Alberta facilities for the 2005 reporting year, organized by facility type. Total reported greenhouse gas emissions were 109 megatonnes (Mt). [Figure 1](#) shows the total reported emissions by greenhouse gas. Carbon dioxide made up 95 per cent of the total reported Alberta greenhouse gas emissions, or 104 Mt. Three per cent, or four Mt, of the total reported greenhouse gas emissions were in the form of methane (CH<sub>4</sub>) and two per cent, or two Mt, of total reported greenhouse gas emissions were in the form of nitrous oxide (N<sub>2</sub>O). Eight kilotonnes (kt) of greenhouse gases were emitted as hydrofluorocarbons (HFC). None of the Alberta facilities reported emissions of perfluorocarbons (PFC) or sulphur hexafluoride (SF<sub>6</sub>) for the 2005 reporting year.



**Figure 1: 2005 reported Alberta GHG emissions by gas.**

### 3.2 Total GHG emissions by facility type

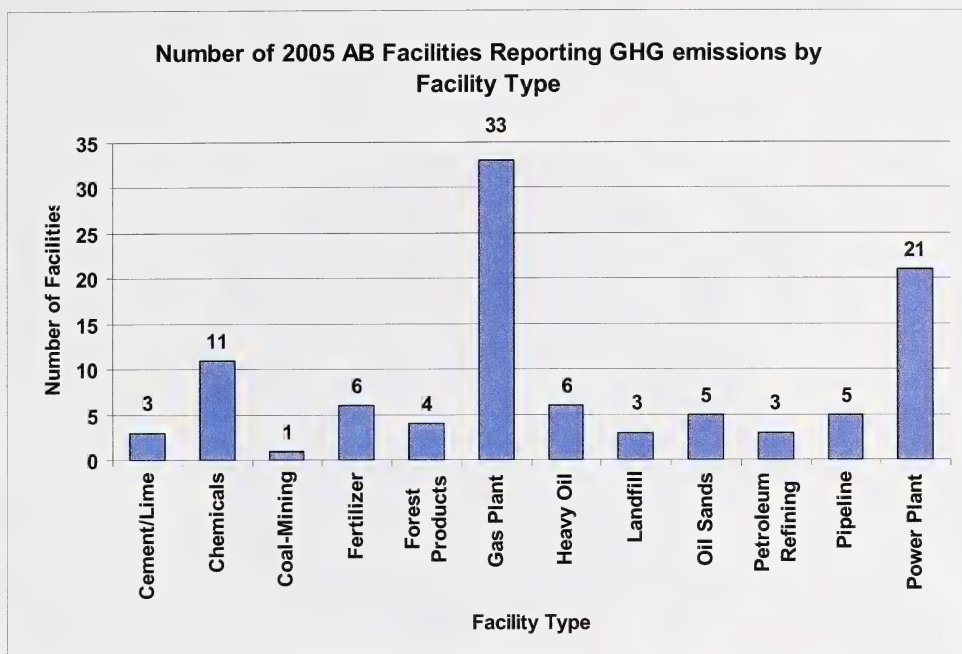
Power plants were the largest source of greenhouse gas emissions in Alberta for the 2005 reporting year (see: [Figure 2](#)). A total of 51 Mt of greenhouse gas emissions were reported by power plant facilities. This accounted for 47 per cent of all Alberta greenhouse gas emissions reporting for the 2005 reporting year. Oil sands facilities were the second largest emitter of greenhouse gases with 20 Mt, which represents 19 per cent of the reported greenhouse gas emissions. Gas plant (nine Mt, eight per cent), chemicals (seven Mt, six per cent) and heavy oil facilities (seven Mt, six per cent) were also large sources of reported greenhouse gas emissions. In [Figure 2](#), coal-mining, forest products, landfill, cement/lime, pipeline, petroleum refining and fertilizer facilities were included in the “other” category (16 Mt, 14 per cent). [Figure 2](#) presents the reported greenhouse gas emissions by facility type. The 10 largest emitting facilities were from the power plant, oil sands, heavy oil, chemicals and pipeline sectors.



**Figure 2: 2005 reported Alberta GHG emissions by facility type.**

There were 101 Alberta facilities that reported greenhouse gas emissions for 2005 greenhouse gas reporting. The largest number of Alberta facilities that reported greenhouse gas emissions for the 2005 reporting year were gas plants (33). There were 21 Alberta power plants and 11 chemical facilities that reported greenhouse gas emissions for 2005 reporting. The remaining facility types each had six or fewer facilities reporting greenhouse gas emissions. [Figure 3](#) provides an overview of the number of Alberta facilities that reported greenhouse gas emissions by facility type.



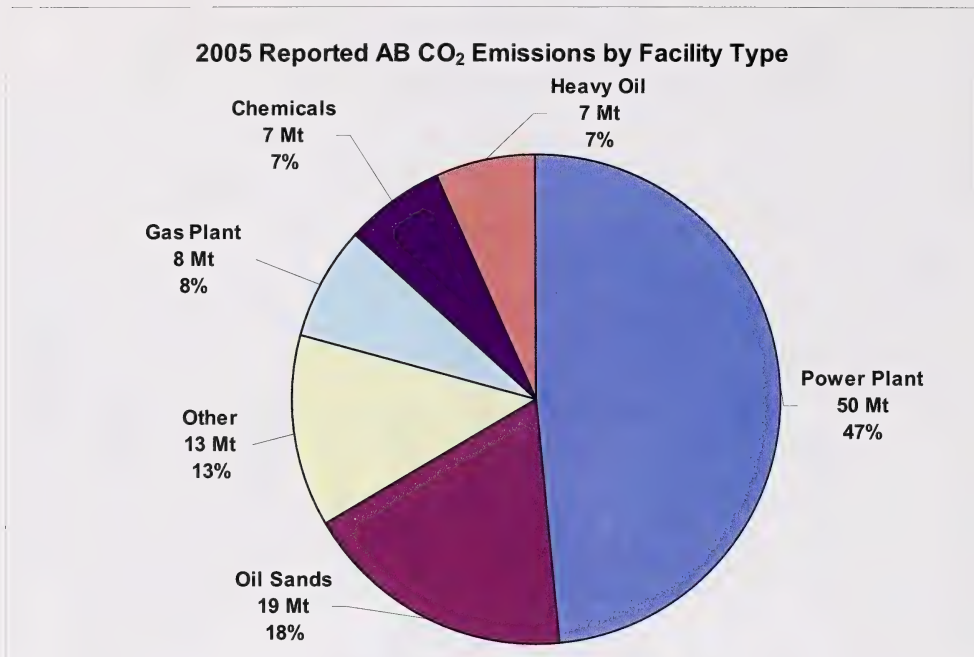


**Figure 3: Number of 2005 Alberta facilities reporting GHG emissions by facility type.**

### **3.3 Emissions by GHG Gas type**

#### **3.3.1 Carbon dioxide emissions**

Power plants were the largest source of carbon dioxide (CO<sub>2</sub>) emissions for the 2005 reporting year, with a total of 50 Mt of CO<sub>2</sub> emissions (see: [Figure 4](#)). This accounted for 47 per cent of all Alberta CO<sub>2</sub> emissions reported for 2005. Oil sands facilities were the second largest emitter of CO<sub>2</sub> with 19 Mt or 18 per cent of reported emissions. Gas plant (eight Mt, eight per cent), chemicals (seven Mt, seven per cent) and heavy oil facilities (seven Mt, seven per cent) were also large sources of reported CO<sub>2</sub> emissions. In [Figure 4](#) landfill, coal-mining, forest products, cement/lime, pipeline, fertilizer and petroleum refining facilities were included in the “other” category (13 Mt, 13%). [Figure 4](#) presents the reported CO<sub>2</sub> emissions by facility type.

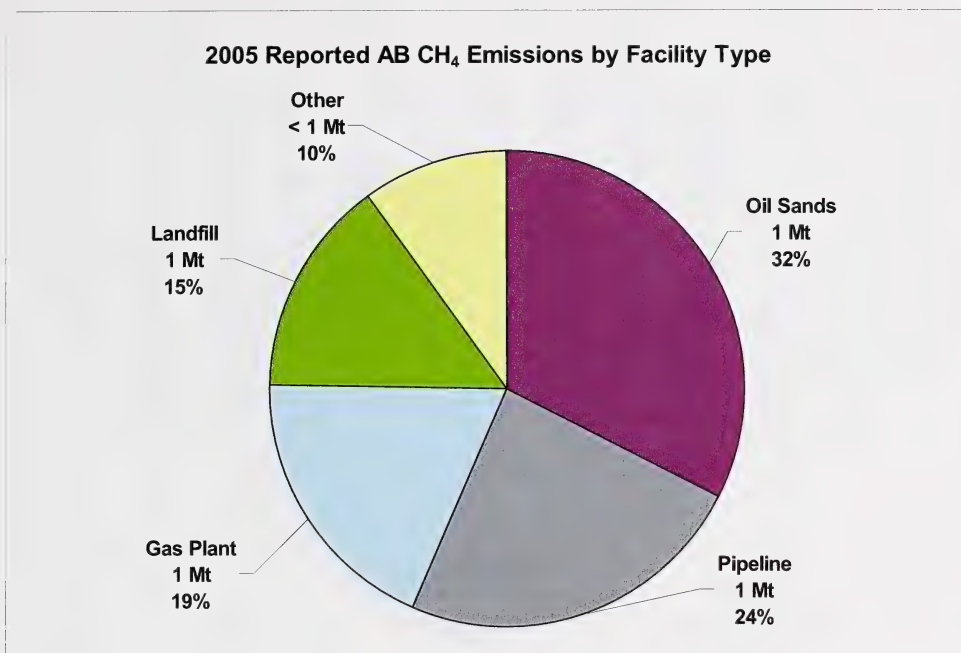


**Figure 4: 2005 reported Alberta CO<sub>2</sub> emissions by facility type.**

### **3.3.2 Methane emissions**

Oil sands facilities were the largest source of methane (CH<sub>4</sub>) emissions in 2005, with a total of 1Mt of CH<sub>4</sub> emissions, which accounted for 32 per cent of all Alberta CH<sub>4</sub> emissions being reported for 2005. Pipeline facilities reported the second largest portion of CH<sub>4</sub> emissions (1 Mt, 24 per cent), followed by gas plant (1 Mt, 19 per cent) and landfill facilities (1 Mt, 15 per cent). In [Figure 5](#) cement/lime, petroleum refining, chemicals, fertilizer, power plant, forest products, coal-mining and heavy oil facilities were included in the “other” category (less than 1 Mt, 10 per cent). [Figure 5](#) presents the reported CH<sub>4</sub> emissions by facility type.

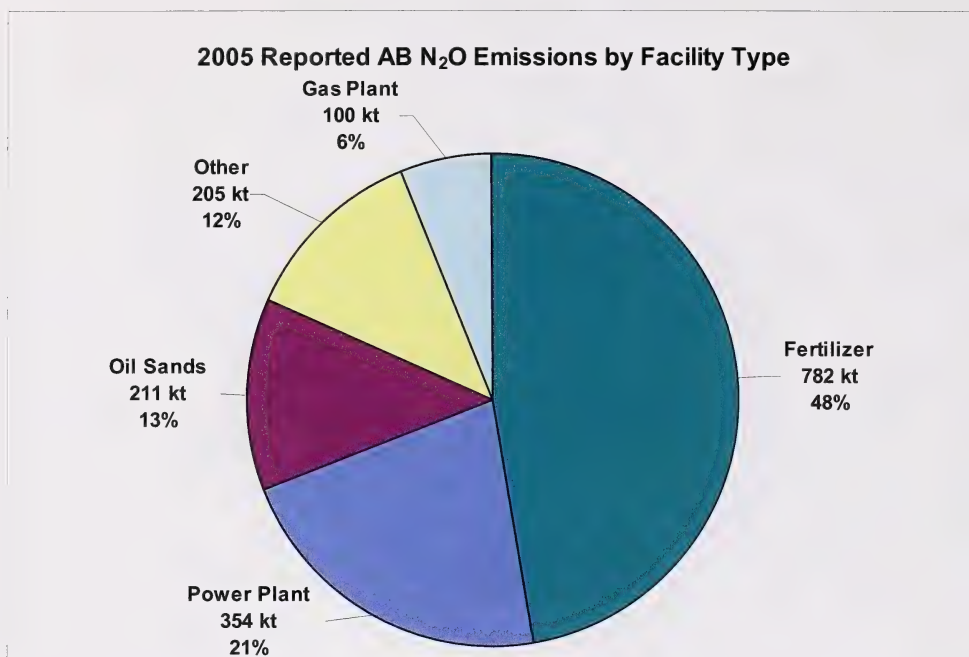




**Figure 5: 2005 reported Alberta CH<sub>4</sub> emissions by facility type.**

### **3.3.3 Nitrous oxide emissions**

Fertilizer facilities were the largest source of nitrous oxide (N<sub>2</sub>O) emissions reported for 2005, with a total of 782 kt of N<sub>2</sub>O, which accounted for 48 per cent of all Alberta N<sub>2</sub>O emissions reported for 2005. Power plants were the source of the second largest portion of N<sub>2</sub>O emissions with 354 kt or 21 per cent of reported emissions, followed by oil sands (211 kt, 13 per cent) and gas plant facilities (100 kt, 6 per cent). In [Figure 6](#) landfill, coal-mining, cement/lime, petroleum refining, chemicals, pipeline, forest products and heavy oil facilities were included in the “other” category (205 kt, 12 per cent). [Figure 6](#) presents the reported N<sub>2</sub>O emissions by facility type in kt.



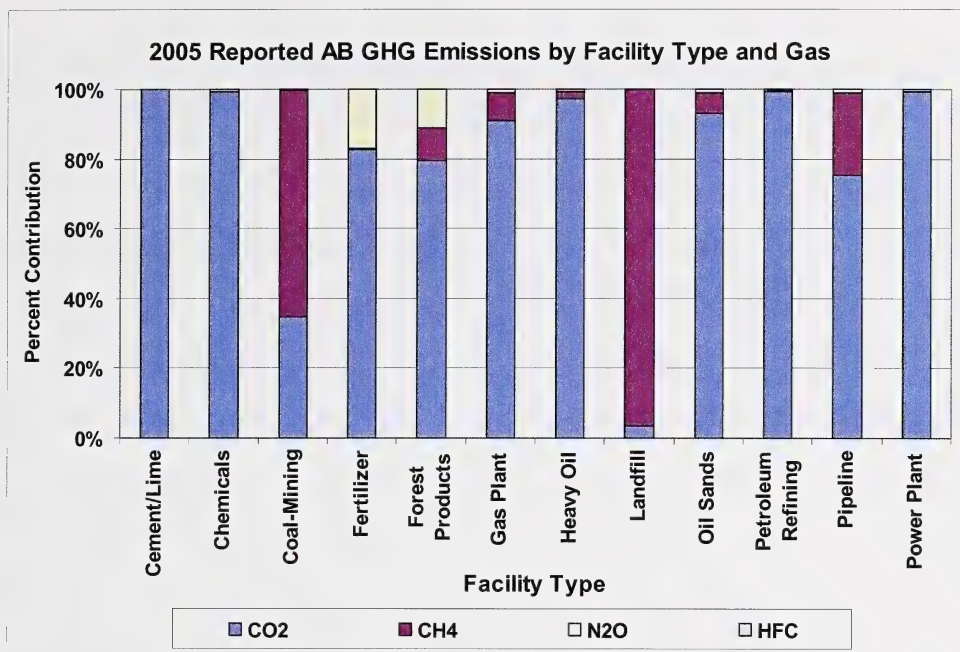
**Figure 6: 2005 reported Alberta N<sub>2</sub>O emissions by facility type in kt.**

### **3.3.4 Emissions of hydrofluorocarbons**

Chemical facilities were the largest source of hydrofluorocarbons (HFC) reported for 2005 with a total of eight kt of HFC emissions, which accounted for more than 99 per cent of all Alberta HFC emissions reported for 2005. Petroleum refining facilities were the other source of reported HFC emissions with less than one kt of HFC emissions reported for 2005.

### **3.4 Reported emissions by facility type and GHG gas type**

For most facility types, CO<sub>2</sub> emissions constituted the majority of reported total greenhouse gas emissions. [Figure 7](#) presents the percentage contribution of each greenhouse gas to the total reported greenhouse gas emissions for each facility type for 2005. CH<sub>4</sub> was a major reported greenhouse gas for coal-mining, landfill and pipeline facilities. N<sub>2</sub>O emissions were a significant source for fertilizer and forest products facilities.



**Figure 7: 2005 reported Alberta GHG emissions by facility type and gas.**



## 4.0 Comparison of 2005 to 2004 GHG emissions

The 2005 reporting year was the third year of mandatory greenhouse gas emissions reporting for large industrial facilities in the Alberta. Approximately 100 Alberta facilities reported during the first three years. The facilities reporting have varied somewhat between years, due to some facilities falling above or below the reporting threshold of 100 kt. This section of the report compares the total reported emissions between the 2004 and 2005 reporting years.

There is some question as to how comparable emissions are between the reporting years, as calculation methods and reference materials used by facilities in determining greenhouse gas emissions may change from year to year. Currently, with the information collected, it cannot be determined if a facility changed its emission calculation methodologies between reporting years.

In addition, it should be noted that industrial sectors are not required to use the same calculation methods and reference materials for the same facility types. This could mean that two similar facilities may use different methods to calculate emissions and therefore the emissions of these facilities may not be directly comparable. However, some industry associations have published recommended methodologies for their members to use to calculate greenhouse gas emissions, the use of which is voluntary.

Total reported greenhouse gas emissions were 109 Mt for 2005. This represents a decrease of 0.1 Mt from the 109 Mt of greenhouse gas emissions reported for 2004<sup>1</sup>. In 2005, 101 Alberta facilities reporting greenhouse gas emissions for 2005, whereas in 2004 98 facilities reported greenhouse gas emissions. The increase was seen with chemicals (one), landfill (two) and power plant (two) facility types. The number of gas plant facilities reporting for 2005 decreased by two as compared to 2004. Changes in the number of facilities reporting greenhouse gas emissions between years is due to facilities voluntarily reporting, changes in production or operations that affect whether a facility exceeds the reporting threshold or emission reduction programs that affect whether a facility exceeds the reporting threshold.

There were 94 Alberta facilities that reported greenhouse gas emissions in both the 2004 and 2005 reporting years. The net change in emissions for these 94 facilities was a decrease of 0.3 Mt between 2004 and 2005, with 44 facilities reporting higher emissions for 2005 than 2004 and 50 facilities reporting lower emissions for 2005 as compared to 2004.

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<sup>1</sup> Note that the 2004 emission numbers used here are different from the numbers in the report: *Specified Gas Reporting: Alberta's 2004 Industrial Greenhouse Gas Emissions*, due to facility reporting errors that in the meantime have been corrected.

**Table 2: 2004 and 2005 comparable facilities seeing higher or lower emissions.**

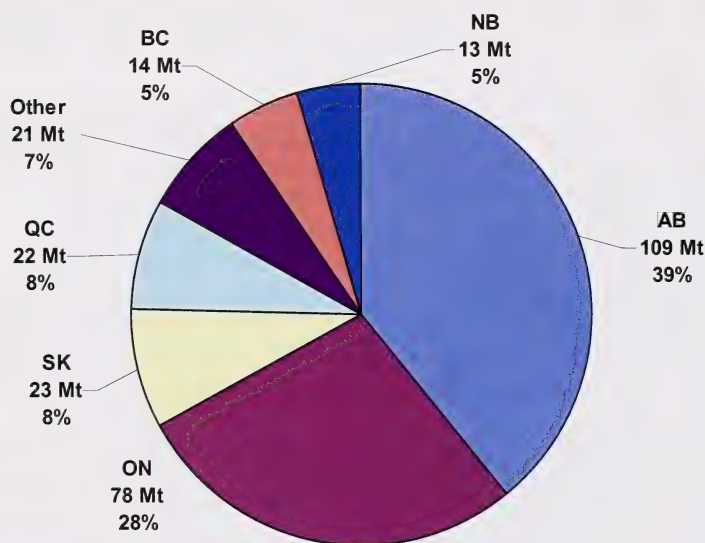
<b>Facility Type</b>	<b>Comparable Facilities</b>	<b>Facilities Reporting Higher Emissions</b>	<b>Facilities Reporting Lower Emissions</b>
<b>Cement/Lime</b>	3	1	2
<b>Chemicals</b>	10	6	4
<b>Coal-Mining</b>	1	1	0
<b>Fertilizer</b>	6	3	3
<b>Forest Products</b>	4	1	3
<b>Gas Plant</b>	32	14	18
<b>Heavy Oil</b>	6	3	3
<b>Landfill</b>	1	1	0
<b>Oil Sands</b>	5	0	5
<b>Petroleum Refining</b>	3	1	2
<b>Pipeline</b>	5	5	0
<b>Power Plant</b>	18	8	10
<b>Total:</b>	94	44	50

## 5.0 2005 National GHG Reporting

### 5.1 2005 reported GHG emissions by province

The *National Mandatory Greenhouse Gas Reporting Program*<sup>vi</sup> collected reported greenhouse gas emissions data for all large industrial facilities emitting more than 100 kt of greenhouse gas emissions. Of the 280 Mt of total Canadian greenhouse gas emissions reported for 2005, Alberta had the highest reported emissions with 109 Mt or 39 per cent of the total reported emissions. Ontario was the second largest emitting province of reported emissions with 78 Mt or 28 per cent of reported greenhouse gas emissions followed by Saskatchewan (23 Mt, eight per cent), Quebec (22 Mt, eight per cent), British Columbia (14 Mt, five per cent) and New Brunswick (13 Mt, five per cent). Figure 8 shows the percentage contribution of each province/territory to 2005 total reported Canadian greenhouse gas emissions. In Figure 8 emissions reported by facilities in Nova Scotia, Newfoundland & Labrador, Manitoba, Northwest Territories and Prince Edward Island were included in the “other” category (21 Mt).

**2005 Total Reported GHG Emissions by Province/Territory**



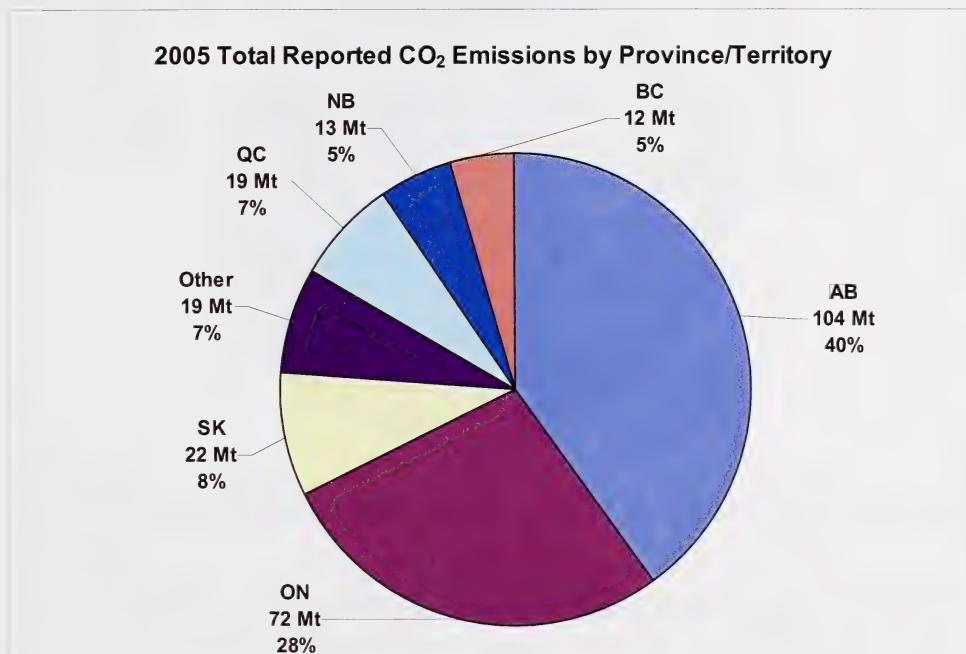
**Figure 8: 2005 total reported GHG emissions by province/territory.**

#### 5.1.1 Reported carbon dioxide emissions by province

Of the 261 Mt of total reported carbon dioxide (CO<sub>2</sub>) emissions reported for 2005 greenhouse gas reporting, Alberta was the source of the largest share of reported emissions with 104 Mt or 40 per cent of the reported emissions followed by Ontario (72 Mt, 28 per cent), Saskatchewan (22 Mt, eight per cent), Quebec (19 Mt, seven per



cent), New Brunswick (13 Mt, five per cent) and British Columbia (12 Mt, five per cent). Figure 9 shows the percentage contribution of each province/territory to 2005 total reported Canadian CO<sub>2</sub> emissions. In Figure 9 emissions reported by facilities in Nova Scotia, Newfoundland & Labrador, Manitoba, Northwest Territories and Prince Edward Island were included in the “other” category (19 Mt).



**Figure 9: 2005 total reported CO<sub>2</sub> emissions by province/territory.**

### 5.1.2 Reported methane emissions by province

Of the nine Mt of total methane (CH<sub>4</sub>) emissions reported for 2005 greenhouse gas reporting, Alberta was the source of the largest share of reported emissions with four Mt or 43 per cent followed by Ontario (two Mt, 23 per cent), British Columbia (one Mt, 11 per cent), Saskatchewan (one Mt, nine per cent) and Manitoba (one Mt, seven per cent). Figure 10 shows the percentage contribution of each province/territory to 2005 total reported Canadian CH<sub>4</sub> emissions. In Figure 10 emissions reported by facilities in Quebec, Newfoundland & Labrador, New Brunswick, Nova Scotia and the Northwest Territories were included in the “other” category (one Mt).

### 2005 Total Reported CH<sub>4</sub> Emissions by Province/Territory

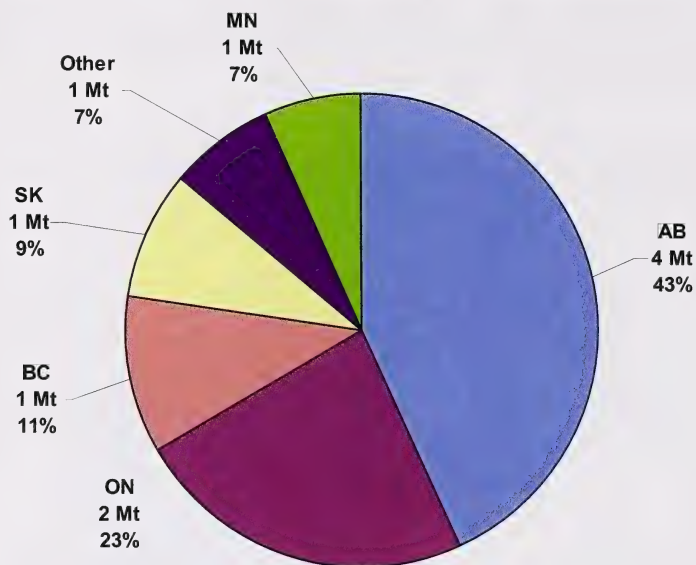


Figure 10: 2005 total reported CH<sub>4</sub> emissions by province/territory.

### 5.1.3 Reported nitrous oxide emissions by province

Of the six Mt of total reported nitrous oxide (N<sub>2</sub>O) emissions reported for 2005 greenhouse gas reporting, Ontario was the source of the largest share of reported emissions with three Mt or 50 per cent of the reported emissions followed by Alberta (two Mt, 26 per cent), Nova Scotia (one Mt, nine per cent) and British Columbia (less than one Mt, seven per cent). [Figure 11](#) shows the percentage contribution of each province/territory to 2005 total reported Canadian N<sub>2</sub>O emissions. In [Figure 11](#) emissions reported by facilities in Saskatchewan, Quebec, Manitoba, New Brunswick, Newfoundland & Labrador, Northwest Territories and Prince Edward Island were included in the “other” category (less than one Mt).

### 2005 Total Reported N<sub>2</sub>O Emissions by Province/Territory

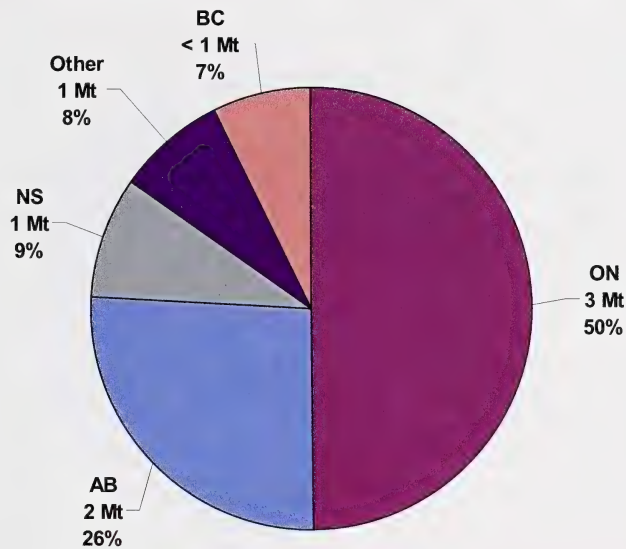


Figure 11: 2005 total reported N<sub>2</sub>O emissions by province/territory.

#### 5.1.4 Reported emissions of hydrofluorocarbons by province

Of the 53 kt of total emissions of hydrofluorocarbons (HFC) reported for 2005 greenhouse gas reporting, Quebec was the source of the largest share of reported emissions with 41 kt or 78 per cent followed by Alberta (eight kt, 15 per cent). [Figure 12](#) shows the percentage contribution of each province/territory to 2005 total reported Canadian HFC emissions in kt. In [Figure 12](#), emissions reported by facilities in Newfoundland & Labrador, Ontario, Northwest Territories, British Columbia, Manitoba and Saskatchewan were included in the “other” category (4 kt).



### 2005 Total Reported HFC Emissions by Province/Territory

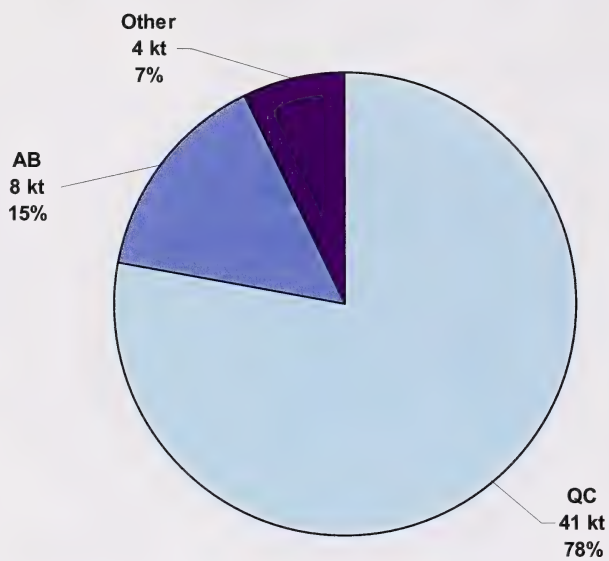


Figure 12: 2005 total reported HFC emissions by province/territory in kt.

## 6.0 Comparison to national inventory (2004)

The *National Greenhouse Gas Inventory*<sup>vi</sup> is prepared in accordance with Canada's obligations under the *United Nations Framework Convention on Climate Change*<sup>vii</sup> (UNFCCC). The UNFCCC reporting guidelines include guidelines developed by the *Intergovernmental Panel on Climate Change*<sup>viii</sup> that set out how greenhouse gas emissions inventories are prepared and what is included in the national inventory report. In addition to industrial sources, the *National Greenhouse Gas Inventory* also includes estimates of greenhouse gas emissions from other sources including transportation, agriculture, construction, commercial, institutional and residential. The *National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2004*, which was published in April 2006, contains the most recent National Greenhouse Gas Inventory. The *National Inventory* includes national, provincial and territorial greenhouse gas emissions. Alberta Environment uses this *Inventory* and the emissions information collected through the *Specified Gas Reporting Program*<sup>ii</sup> as a basis of analysis for greenhouse gas emissions and trends for Alberta. The information is used for issue identification, policy development and evaluation of current Alberta actions on climate change.

### 6.1 Reporting program coverage

The *National Greenhouse Gas Inventory*<sup>vii</sup> provides Alberta greenhouse gas emissions from all sources; while the *Specified Gas Reporting Program*<sup>ii</sup> focuses only on greenhouse gas emissions from large industrial sources in the province that meet or exceed the 100 kt reporting threshold. The following assumes that 2004 inventory values will be within one per cent of 2005 inventory as the 2005 reported Alberta values decreased by less than one per cent.

- The 2004 *National Greenhouse Gas Inventory* estimated total 2004 Alberta greenhouse gas emissions of 235 Mt, while the 2005 reported greenhouse gas emissions from the *Specified Gas Reporting Program* were 109 Mt. Therefore the current *Specified Gas Reporting Program* is capturing about 47 per cent of all the greenhouse gas emissions in the province.
- Total Alberta carbon dioxide (CO<sub>2</sub>) emissions estimated in the 2004 *National Greenhouse Inventory* were 184 Mt, while total reported CO<sub>2</sub> emissions were 104 Mt. Therefore, the current Alberta *Specified Gas Reporting Program* is capturing 57 per cent of all CO<sub>2</sub> emissions in the province.
- Total Alberta methane (CH<sub>4</sub>) emissions estimated in the *National Inventory* were 40 Mt, while reported CH<sub>4</sub> emissions were 3.7 Mt. The current *Reporting Program* is therefore capturing nine per cent of all CH<sub>4</sub> emissions in the province.

- Total Alberta nitrous oxide (N<sub>2</sub>O) emissions estimated in the *National Inventory* were 11 Mt, while N<sub>2</sub>O reported emissions were 1.7 Mt. The current *Reporting Program* is therefore capturing 15 per cent of N<sub>2</sub>O emissions in the province.
- Industrial sources in Alberta accounted for in the 2004 *National Greenhouse Gas Inventory* totalled 172 Mt or 73 per cent of total greenhouse gas emissions. Total reported 2005 greenhouse gas emissions in Alberta were 109 Mt. The current *Specified Gas Reporting Program* is therefore capturing 64 per cent of the total industrial greenhouse gas emissions in the province.

## 6.2 Greenhouse gases

A total of 235 Mt of greenhouse gases were emitted from all sources in Alberta according to the 2004 *National Greenhouse Gas Inventory*<sup>vii</sup>. Of these emissions, 184 Mt or 78 per cent were in the form of carbon dioxide (CO<sub>2</sub>). Forty Mt or 17 per cent of total greenhouse gas emissions were in the form of methane (CH<sub>4</sub>). The remaining five per cent or 11 Mt of greenhouse gas emissions in Alberta were in the form of nitrous oxide (N<sub>2</sub>O). There were no significant sources of emissions of hydrofluorocarbons (HFC), perfluorocarbons (PFC) or sulphur hexafluoride (SF<sub>6</sub>) in Alberta according to the *National Inventory*. Figure 13 shows the total 2004 greenhouse gas emissions in Alberta by gas.

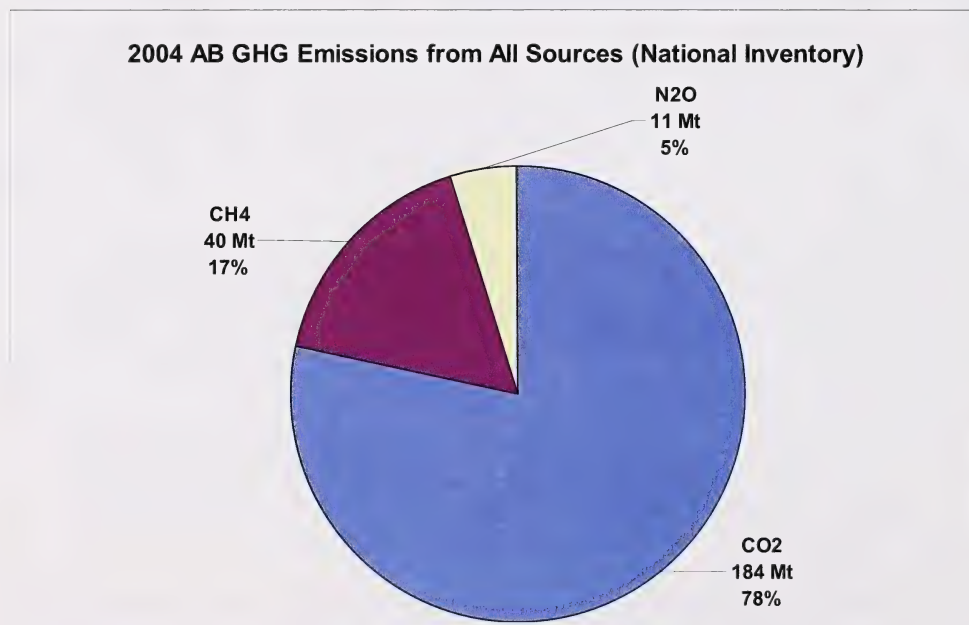


Figure 13: 2004 Alberta GHG emissions from all sources (National Inventory).



### **6.3 Largest greenhouse gas sources**

Six sources were responsible for the majority (210 Mt, 89 per cent) of the total of 2004 greenhouse gas emissions (235 Mt). Fossil fuel industries including pipelines and fugitive sources from coal mining and oil and natural gas were the largest source of greenhouse gas emissions in Alberta (87 Mt, 37 per cent). Electricity and heat generation were the second largest sources of greenhouse gas emissions in Alberta with (53 Mt, 22 per cent) followed by transportation sources excluding pipelines (30 Mt, 13 per cent), agriculture (17 Mt, seven per cent), industrial processes (13 Mt, six per cent) and mining (11 Mt, five per cent). The remaining sources of greenhouse gases in Alberta accounted for the 25 Mt or 11 per cent of total 2004 greenhouse gas emissions.

## 7.0 GHG trends since 1990

Alberta has set a target of a 50 per cent emissions intensity reduction below 1990 levels by 2020. Emissions intensity is a measure of the quantity of greenhouse gas emissions (in kilotonnes) compared to the size of the Alberta gross domestic product (in dollars). An interim target of a 30 per cent reduction in intensity by 2010 was also established. Greenhouse gas emissions intensity is also reported as one of Alberta's *State of the Environment*<sup>ix</sup> performance indicators.

Total absolute Alberta inventory greenhouse gas emissions from all sources have increased by 67 Mt or 40 per cent between 1990 and 2004 (from 168 Mt to 235 Mt). [Figure 14](#) shows the total Alberta greenhouse gas emissions from 1990 to 2004. All provinces and territories except the Yukon have seen greenhouse gas emissions increase between 1990 and 2004. Alberta's 40 per cent increase was the third largest after Saskatchewan (62 per cent) and New Brunswick (47 per cent).

While total absolute greenhouse gas emissions have been increasing in Alberta, emissions intensity of greenhouse gas emissions improved by 16 per cent (see: [Figure 15](#)). Alberta is more than one quarter of the way to meeting its target of reducing emissions intensity by 50 per cent below 1990 levels. Furthermore, Alberta is over half way to meeting its interim 2010 target of a 30 per cent reduction.

Alberta's total greenhouse gas emissions were 168 Mt in 1990 with Alberta's Gross Domestic Product at \$82,227 million dollars (1997 dollars) in 1990. The ratio of the greenhouse gas emissions per GDP gives an intensity value of 2.04 for 1990. In 2004 Alberta's total greenhouse gas emissions were 235 Mt with a GDP of \$135,837 million dollars (1997 dollars). The ratio of the greenhouse gas emissions per GDP gives an intensity value of 1.73 in 2004. Although Alberta's total greenhouse gas emissions have increased since 1990, the province's economy has grown at a much faster rate resulting in an improvement in emissions intensity.

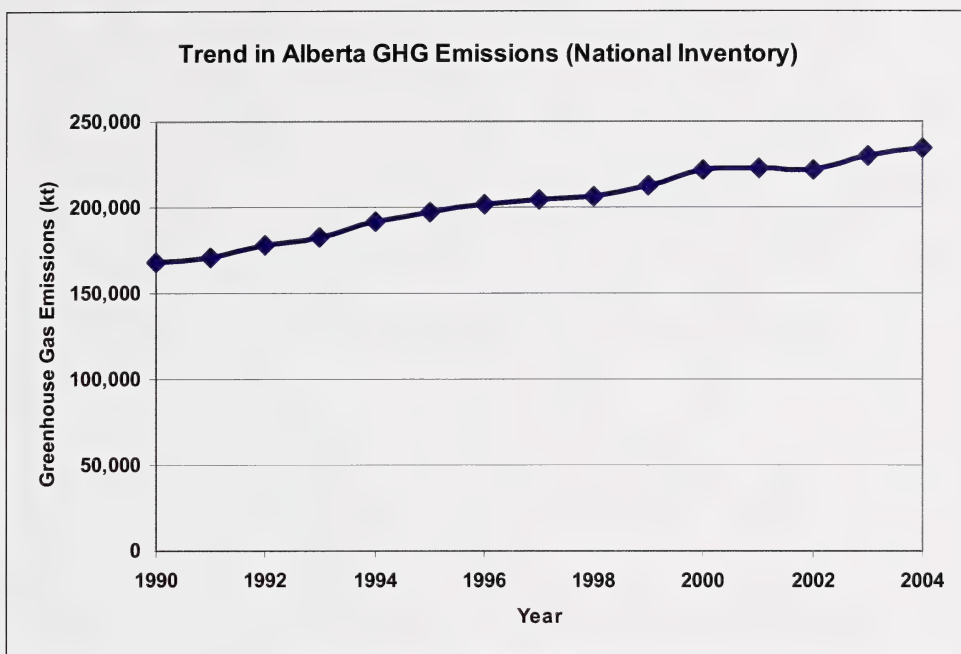


Figure 14: Trends in Alberta greenhouse gas emissions (National Inventory).

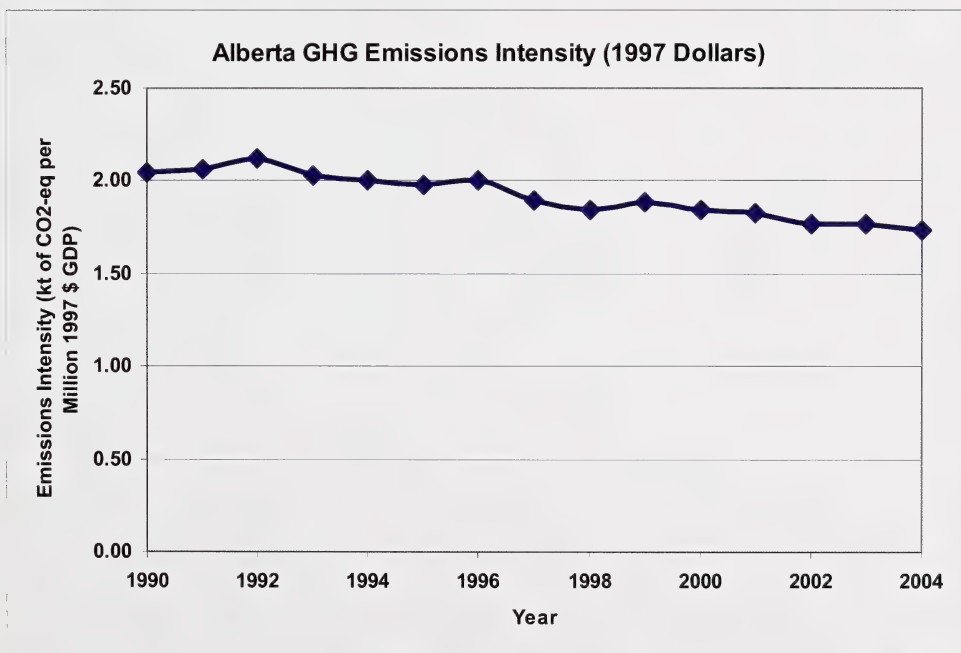


Figure 15: Alberta GHG emissions intensity (1997 Dollars).





## **Appendix**

Table 3: Total 2005 reported greenhouse gas emissions by facility type.

Facility Type	Reporting Company	Facility Name	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	HFC (kt)	Total GHG (kt)
Cement/Lime	Lafarge Canada Inc	Exshaw Cement Plant	1,094	0	0		1,094
Cement/Lime	Graymont Western Canada Inc.	Exshaw	Confidential	Confidential	Confidential	Confidential	Confidential
Cement/Lime	Lehigh Inland Cement Limited	Lehigh Inland Cement	962	0	2		963
Chemicals	Innovene Canada Partnership	Joffre LAO Plant	114	0	1		115
Chemicals	Dow Chemical Canada Inc.	Western Canada Operations	1,596	1	3	7	1,607
Chemicals	Celanese Canada Inc.	Edmonton Facility	610	1	3		613
Chemicals	NOVA Chemicals Corporation	NOVA Chemicals Corporation (Joffre)	3,032	3	14		3,049
Chemicals	MEGlobal Canada Inc.	FS1 EOEG	113	1			114
Chemicals	Air Liquide Canada Inc.	Scotford Complex	330	0	3		333
Chemicals	Alberta Envirofuels Inc.	Alberta Envirofuels Inc.	319	1	2		322
Chemicals	MEGlobal Canada Inc.	Prentiss Manufacturing Facility	384	2	0		386
Chemicals	Shell Chemicals Canada Ltd	Scotford Chemical Plant	290	0	1	1	292
Chemicals	Cancarb Ltd.	Cancarb Ltd.	132	0	2		134
Chemicals	Alcan Inc 1188 Sherbrooke Ouest	Alcan Inc - Strathcona works	101	0	5		107
Coal-Mining	TransAlta Utilities Corporation	Highvale Coal Mine	65	121	1		186
Fertilizer	Agrium Inc	Carseland Nitrogen Operations	519	0	2		521
Fertilizer	Sherritt International Corporation	Fort Saskatchewan	278	0	1	0	279



Facility Type	Reporting Company	Facility Name	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	HFC (kt)	Total GHG (kt)
Fertilizer	Canadian Fertilizers Limited	Canadian Fertilizers Limited	1,432	0	5		1,437
Fertilizer	Orica Canada Inc	Carseland Works	0		756		756
Fertilizer	Agrium Inc.	Agrium Redwater Fertilizer Operation	1,054	8	17		1,080
Fertilizer	Agrium Inc.	Fort Saskatchewan Nitrogen Operation	497	1	2		500
Forest Products	Weyerhaeuser Company Limited	Grande Prairie Operations	92	30	11		132
Forest Products	West Fraser Mills Ltd.	Hinton Pulp	136	1	11		149
Forest Products	Alberta-Pacific Forest Industries Inc. acting as a	Alberta-Pacific Forest Industries Inc. Pulp Mill	79	2	19		99
Forest Products	Daishowa-Marubeni International Ltd.-Peace River Pu	Peace River Pulp Division	62	10	11		83
Gas Plant	Shell Canada Limited	Shell Caroline Complex	640	82	4		726
Gas Plant	Bonavista Petroleum Ltd.	Carstairs - Crossfield Gas Plant	43	1	0		45
Gas Plant	Imperial Oil Resources	Quirk Creek Gas Plant	119	13	1		133
Gas Plant	Imperial Oil Resources	Bonnie Glen Gas Plant	324	31	5		359
Gas Plant	Petro-Canada	Brazeau Gas Plant	140	14	2		157
Gas Plant	Petro-Canada	Hanlan Robb Gas Plant	600	28	6		634
Gas Plant	Petro-Canada	Wildcat Hills Gas Plant	249	9	2		259
Gas Plant	Shell Canada Limited	Waterton Complex	484	88	6		578
Gas Plant	Shell Canada Limited	Shell Jumping Pound Gas Plant	244	74	2		320
Gas Plant	Nexen Inc.	Balzac Gas Processing Plant	226	4	2		232
Gas Plant	Anadarko Canada Corporation	Progress Gas Plant	125	5	1		131

Facility Type	Reporting Company	Facility Name	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	HFC (kt)	Total GHG (kt)
Gas Plant	PrimeWest Energy Inc.	East Crossfield Gas Plant 9-14-28-1W5	185	4	2		190
Gas Plant	Devon Canada Corporation	Wapiti Gas Plant	127	20	1		148
Gas Plant	Talisman Energy Inc.	Edson Gas Plant	260	12	4		277
Gas Plant	Pengrowth Corporation	Judy Creek Gas Conservation Plant	121	25	6		152
Gas Plant	BP Canada Energy Company	Fort Saskatchewan Storage & Fractionation	98	0	0		99
Gas Plant	Taylor Processing Inc.	Harmatman Gas Processing Plant	238	15	2		255
Gas Plant	EnCana Corporation	Caribou North Compressor Station	85	22	11		118
Gas Plant	Inter Pipeline Extraction Ltd.	Cochrane Extraction Plant	357	6	4		366
Gas Plant	Pengrowth Corporation	Judy Creek Production Complex	84	12	5		102
Gas Plant	Keyera Energy	Strachan GP	248	4	3		255
Gas Plant	Keyera Energy	Brazeau GP	83	6	4		93
Gas Plant	Keyera Energy	Rimbey Gas Plant	236	7	3		247
Gas Plant	Apache Canada Ltd.	Zama Gas Plant: 1, 2, 3	79	60	5		145
Gas Plant	Husky Energy	Ram River	872	7	2		881
Gas Plant	Shell Canada Limited	Shell Burnt Timber Gas Plant	201	70	1		272
Gas Plant	Duke Energy Field Services Canada	Nevis Gas Plant	121	6	0		127
Gas Plant	Duke Energy Empress LP	Empress straddle plant system	171	3	3		177
Gas Plant	ConocoPhillips Canada	Elmworth Gas Plant	269	14	6		288
Gas Plant	SemCams	KA 1-12 GP	197	14	2		213

Facility Type	Reporting Company	Facility Name	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	HFC (kt)	Total GHG (kt)
Gas Plant	SemCams	K3 1-15 GP	437	7	1		445
Gas Plant	SemCams	Windfall 8-17 GP	146	11	3		159
Gas Plant	Duke Energy Field Services Canada	Tooga Plant	125	20	0		145
Heavy Oil	Imperial Oil Resources	Cold Lake	4,100	10	18		4,128
Heavy Oil	Shell Canada Limited	Peace River Complex	365	43	6		414
Heavy Oil	Japan Canada Oil Sands Limited	Hangstone SAGD Demonstration Facility	211	0	19		230
Heavy Oil	Canadian Natural Resources Limited	Wolf Lake/Primrose Thermal Operation	1,772	94	15		1,881
Heavy Oil	EnCana Corporation	Foster Creek SAGD Bitumen Battery	262	0	0		262
Heavy Oil	EnCana Corporation	Christina Lake SAGD Bitumen Battery	110	0	0		111
Landfill	City of Calgary	East Calgary Landfill	20	151			171
Landfill	Waste Management of Canada Corporation	West Edmonton Landfill		278			278
Landfill	Waste Management of Canada Corporation	Ryley Landfill		102			102
Oil Sands	Shell Canada Limited	Scotford Upgrader and Upgrader Cogeneration	1,916	4	12		1,932
Oil Sands	Petro-Canada	MacKay River, In-Situ Oil Sands Plant	122	49	2		173
Oil Sands	Synchrude Canada Ltd.	Mildred Lake and Aurora North Plant Sites	9,559	699	99		10,357
Oil Sands	Suncor Energy Inc. Oil Sands	Suncor Energy Inc. Oil Sands	7,212	400	83		7,694
Oil Sands	Albian Sands Energy Inc.	Muskeg River Mine	193	40	15		247
Petroleum Refining	Petro-Canada	Edmonton Refinery	1,520	6	8	0	1,534



Facility Type	Reporting Company	Facility Name	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	HFC (kt)	Total GHG (kt)
Petroleum Refining	Shell Canada Products	Shell Scotford Refinery	915	0	2		918
Petroleum Refining	Imperial Oil Limited	Strathcona Refinery	1,364	0	9	0	1,374
Pipeline	ATCO Gas and Pipelines Ltd.	ATCO Pipelines	83	133	2		217
Pipeline	Alliance Pipeline Ltd.	Alberta Pipeline System	533	36	4		573
Pipeline	Nova Gas Transmission Ltd.	Cardinal Lake Compressor Station, Alberta	1,807	447	29		2,283
Pipeline	ATCO Gas and Pipelines Ltd.	distribution system and Carbon Plant	29	238	2		270
Pipeline	Foothills Pipe Lines Ltd.	Acme Compressor Station # 363, Alberta	325	11	4		341
Power Plant	Milner Power Inc.	H.R. Milner Generating Station	914	0	5		920
Power Plant	Alberta Power (2000) Ltd.	Battle River Generating Station	5,466	1	31		5,498
Power Plant	EnCana Corporation	Cavalier Power Plant	118	0	1		120
Power Plant	TransCanada Energy Ltd.	Redwater Cogeneration Facility, Alberta	174	9	2		185
Power Plant	EPCOR Power Development Corporation	Genesee Thermal Generating Station	8,873	2	75		8,949
Power Plant	TransCanada Energy Ltd.	Mackay River Power Plant, Alberta	703	1	9		713
Power Plant	TransCanada Energy Ltd.	Carseland Power Plant, Alberta	338	1	4		343
Power Plant	Alberta Power (2000) Ltd.	Sheerness Generating Station	6,484	2	37		6,523
Power Plant	Alberta Power (2000) Ltd.	Rainbow Lake Generating Station (Units 1-3)	15	0	0		15

Facility Type	Reporting Company	Facility Name	CO <sub>2</sub> (kt)	CH <sub>4</sub> (kt)	N <sub>2</sub> O (kt)	HFC (kt)	Total GHG (kt)
Power Plant	ATCO Power Alberta Ltd.	Rainbow Lake Cogeneration Power Plant (Units 4-5)	269	0	2		271
Power Plant	ATCO Power Canada Ltd.	Muskeg River Cogeneration Power Plant	1,277	1	7		1,285
Power Plant	CITY OF MEDICINE HAT	CITY OF MEDICINE HAT, ELECTRIC UTILITY - GENERATION	239	4	2		245
Power Plant	EnCana Corporation	Foster Creek Cogeneration Facility	480	1	6		487
Power Plant	Calpine Canada Power Ltd	Calpine Calgary Energy Centre	131	0	1		133
Power Plant	TransAlta Cogeneration LP	Fort Saskatchewan Generating Plant	339	1	3		342
Power Plant	TransAlta Utilities Corporation	Wabamun Generating Plant	2,166	1	16		2,183
Power Plant	Transalta Utilities Corporation	Sundance Generating Plant	16,065	4	112		16,181
Power Plant	Transalta Utilities Corporation	Keephills Generating Plant	6,101	1	42		6,144
Power Plant	Alberta Power (2000) Ltd.	Sturgeon Generating Station (Units 1 & 2)	1	0	0		1
Power Plant	ATCO Power Alberta Ltd.	Valleyview Generating Station	5	0	0		5
Power Plant	ATCO Power Alberta Ltd.	Poplar Hill Generating Station	18	0	0		18

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# Introduction

The purpose of this study is to investigate the effects of various factors on the growth of a certain plant species. The study was conducted over a period of six months, during which time the plants were grown under different conditions. The factors being studied include light intensity, water availability, and soil composition. The results of the study will be presented in the following sections.

The first section of the study focuses on the effect of light intensity on plant growth. It was found that plants grown under higher light intensity grew faster and taller than those grown under lower light intensity. This suggests that light is an important factor in plant growth. The second section of the study focuses on the effect of water availability on plant growth. It was found that plants grown under higher water availability grew faster and taller than those grown under lower water availability. This suggests that water is also an important factor in plant growth.

The third section of the study focuses on the effect of soil composition on plant growth. It was found that plants grown in soil with a higher percentage of organic matter grew faster and taller than those grown in soil with a lower percentage of organic matter. This suggests that soil composition is also an important factor in plant growth. The final section of the study discusses the overall results and conclusions.

In conclusion, the study found that light intensity, water availability, and soil composition all have a significant effect on the growth of the plant species. Plants grown under higher light intensity, higher water availability, and soil with a higher percentage of organic matter all grew faster and taller. These findings have important implications for the cultivation of this plant species in different environments.





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